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Geothermal Energy in Romania - Country Update 2015-2019

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ABSTRACT

This country update regarding the geothermal energy use in Romania deals with both deep and shallow geothermal energy. The document presents the latest developments in this field, such as: the evaluation and the new exploitation of the Bucharest geothermal reservoir, the new development of the geothermal district heating in Oradea. Most development in the last years was due to the RONDINE programme, financed by the European Economic Area Grants Financial Mechanism (EEA Grants) and the Romanian Environmental Fund Administration (EFA).

For the shallow geothermal sector, the most representative investment is the GSHP system from ELI NP Magurele, near Bucharest, which has recently entered into operation. However, the shallow geothermal sector encounters great difficulties due to legislative and regulatory acts, presently in force in Romania.

1. DEEP GEOTHERMAL RESOURCES

1.1 Agrippa Ionescu Hospital in Balotesti

One project financed by the RONDINE programme was the geothermal space and tap water heating system for the Agrippa Ionescu Hospital in Balotesti, Ilfov County, North of Bucharest. A new geothermal well was drilled near the hospital. After completion and testing, a line shaft pump was installed in the well (Fig. 1). It can produce up to 35 l/s geothermal water with a wellhead temperature of about 85ºC. The heat plant near the well (Fig. 2) supplies the primary thermal agent to the substation near the hospital that supplies space heating agent and hot tap water to the hospital. The existing natural gas fired boilers are still in place as back-up. The annual geothermal water production is about 270,000 m^3 (depending on the outdoor temperatures in the cold season), and the annual geothermal energy supplied to the hospital about 6,500 MWh_{th}.

The heat depleted geothermal water is disposed of in a nearby river flowing into a small lake, as it does not cause any thermal or chemical pollution.

Figure 1. Production well with line shaft pump.

Figure 2. Geothermal heat plant

1.2 Therme Bucharest

The Therme Bucharest Spa Centre is up to date the largest private investment in a geothermal project in Romania. The company obtained the all needed licences to drill and exploit a new geothermal well. The line shaft pump installed in the well supplies geothermal water of up to almost 90ºC to the plant near the Spa Centre. After treatment to remove all potentially harmful components, the geothermal water is use in on indoor and 9 outdoor pools for health and recreational bathing.

The water in the pools is recirculated, filtered and sterilized, and geothermal water is added to keep its temperature at 33ºC. The indoor luxurious vegetation of flowers and palm trees is individually fed by a computer-controlled system. Geothermal energy is also used to heat the treated indoor air to provide a comfortable ambient. The facility is opened all year round and can accommodate more than 16,000 visitors at the same time.

Unfortunately, technical data was not available to the authors at the time of writing this paper.

1.3 Extension of the Oradea geothermal district heating system

Another RONDINE project was carried out in the City of Oradea (western Romania), which has an over 40 years' experience of using geothermal energy.

A new reinjection well was drilled about 1 km from the production well in the University of Oradea campus (Fig. 3.), and a substation (Fig. 4.) built at the Sports Program Highschool not far from the campus. The line shaft pump in the geothermal well from the University of Oradea campus was replaced and now supplies geothermal water of about 85ºC not only the university substation, but also the new one at the highschool. The new substation supplies the district heating system heating of the highschool and a few other buildings in the vicinity, the rest being used in the university substation.

Figure 3. Drilling the reinjection well.

Figure 4. Sports Program Highschool substation.

The total annual geothermal water produced from the production well is about 21,000 m^3, of which about 20% is used by the university substation. The annual geothermal energy used in the new substation is about 4,700 MWh_{th}, replacing heat produced by the natural gas fired co-generation power plant in Oradea.

After the heat exchangers at the University of Oradea substation were replaced by larger surface ones, the heat depleted geothermal water temperature decreased below 40ºC and can now be reinjected. At present, the entire geothermal water flowrate from the production well can be reinjected at a low wellhead pressure and therefore with a low power consumption of the reinjection pumps (Fig. 5.).

Figure 5. Reinjection well site (storage tank, pump station, and reinjection well shed).

1.4 Other RONDINE projects

Three other projects were financed by the RONDINE programme: two feasibility and reservoir assessment studies and one educational project.

The two studies carried out by Icelandic and Romanian specialists for the cities of Oradea and Beius demonstrated it is possible to further increase the exploitation of both geothermal reservoir and proposed viable scenarios for the development of geothermal energy utilisation.

The educational project offered fellowships to four selected Romanian specialists to attend the 6 months training programme at the UNU Geothermal Training Programme in Iceland (two from companies in the geothermal business and two from the local authorities in Oradea City and Ilfov County). The Icelandic and local experts also organised at the University of Oradea 2 days workshop for experts from local administrations in regions with geothermal resources, ass well as 3 short courses, one week each, on Geothermal energy utilisation, Chemistry of geothermal fluids, and Reservoir assessment and management. The participants were specialists from companies in the geothermal sector (mainly Dafora Holding), local administrations, and University of Oradea students in the bachelor and Master degree programs on renewable energy sources.

2. SHALLOW GEOTHERMAL ENERGY RESOURCES AND EXPLOITATION

2.1 General overview on the shallow geothermal energy use in Romania

The most important shallow geothermal application from Romania is the ELI-NP Extreme Light Infrastructure, which was built in Bucharest-Magurele. ELI-NP is the first pan-European research facility built in Eastern Europe which is oriented on high-level research on ultra-high intensity laser. The heating and cooling output is in the range of 5.4 MW, for a total air-conditioned area of 27000 m^2. The ground source heat exchanger consists of 1080 boreholes at 125 m depth, the whole borehole length is 135000 m.

The total investment cost of about 356 million € is paid mainly from Romania's allocation of EU structural funds.

The present day situation of this investment – according to [4] – is as follows:

- The GSHP system is completed and functional, meaning: boreholes, hydraulics, heat pump units, fan coils, AHUs.
- The "civil" buildings (office building, guest house and cafeteria) are operational.
- The adjacent spaces to lab facilities (access hallways, offices) are completed and functional.
- The lab spaces – equipment still needs to be installed, building & HVAC are finished. The laser facilities are functional, but the Gamma facilities are not finalized due to lack of timely equipment delivery.
- Due to problems in equipment delivery, the research buildings have heating and cooling loads only due to the buildings themselves, but not due to the research equipment.
- The Building Management System has allowed obtaining functioning data for the GSHP system feeding the civil buildings, during the operational year 2017. The results of this monitoring for the 2017 year are presented in [4].

Figure 5. ELI-NP Project (Bucharest – Magurele)

2.2 Further considerations with regard to the shallow geothermal sector in Romania

Unfortunately, there has not been any major progress with regard to the shallow geothermal energy sector in Romania during the last 3 years. Although Romania has benefitted an amount of 100 million euros for Axis 6 "Operational Plan for Large Investments" – dedicated to less used RES (biomass, biogas, geothermal) and to high-efficiency co-generation systems, there were, there were no investment projects approved in these fields mainly because the political reasons prevail upon the technical reasons, and because the RES specialists are not given credit and support for their solutions.

The update of the national data base for shallow geothermal systems is very difficult due to regulatory acts for permits.

The main conclusion is that Romania is lagging behind with the implementation of the European Directives dealing with the RES use and the energy efficiency measures applied to government, public and administrative buildings, and for the investments made from public money. The legislative instruments in the shallow geothermal sector are a real barrier against its evolution and development. The adoption of the new European standards for water boreholes and geothermal boreholes will be more than welcome for the Romanian regulatory domain.

3. CONCLUSIONS

The geothermal energy has a great potential for development in Romania. This potential can be exploited only through a wise national strategy in investments and professional training.

ACKNOWLEDGEMENTS

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TABLES 1-8

Table 1: PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in December 2019	0	0	11,888	24,300	6,759	17,700	1,413	10,600	4,546	8,300	24,606	60,900
Under construction in December 2010												
Funds committed, but not yet under construction in December 2010												
Total projected use by 2025	0	0										

Table 2: UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2014

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe	Annual Energy Produced 2019[3)] GWh/yr	Total under Constr. or Planned MWe
Oradea	CE Iosia	2012	1	N	B	0.05	0	0
Total						0.05	0	0

Table 3: UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

Locality	Type[1)]	Maximum Utilization			Capacity[3)] (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature (°C)			Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor[5)]
			Inlet	Outlet				
Satu Mare	HB	22.9	65	30	3.36	7.00	32.30	0.31
Carei	B	10.3	45	30	0.65	3.00	5.90	0.29
Acas-Beltiug	B	31	68	30	4.93	0.25	3.40	0.02
Tasnad	BH	17	70	25	3.20	0.17	26.23	0.26
Sacuieni	HDBG	58	80	25	13.36	8.20	30.08	0.07
Marghita	HDB	26	65	25	4.35	5.00	14.57	0.11
Boghis	BH	12	45	25	1.00	5.00	7.23	0.23
*Mihai Bravu	GF	6	65	25	1.00	0.00	0.00	0.00
Sannicoau de Munte	B	5	65	25	0.84	0.17	0.74	0.03
Bors	D	25	120	40	8.37	3.00	6.64	0.03
**Oradea	HDB	90	87	30	21.48	65	345.76	0.51
Livada	DG	10	88	30	2.43	9.00	2.26	0.03
Felix	BH	140	45	25	11.72	95.00	250.61	0.68
Madaras	BH	7	46	25	0.62	0.16	1.19	0.06
Ciumeghiu	G	12	92	35	2.86	0.00	0.00	0.00
Cighid	HB	10	72	25	1.97	0.37	2.75	0.04
Beius	HDB	120	84	30	27.13	15.48	158.46	0.19
Santandrei	F	25	79	35	4.61	2.00	9.70	0.07
Macea	HGB	12	57	30	1.36	10.00	19.53	0.46
Curtici	HGB	16	57	30	1.81	13.00	25.39	0.45
Dorobanti	GB	12	57	30	1.36	5.00	9.77	0.23
*Sofronea	HB	6	50	30	0.50	0.00	0.00	0.00
Arad	B	12	40	25	0.75	7.00	7.60	0.32
Nadlac	IDB	10	75	35	1.67	5.00	14.47	0.27
Sannicolau	IDB	15	78	35	2.70	5.00	15.55	0.18
Saravale	HB	8	75	35	1.34	0.00	0.00	0.00
Tomnatic	GB	45	78	35	8.10	0.00	0.00	0.00
Lovrin	DGB	8	78	35	1.44	5.20	30.02	0.66
*Periam	HB	10	70	35	1.47	0.00	0.00	0.00
Jimbolia	IDBG	8	78	35	1.44	1.00	5.67	0.12
*Teremia	GHB	10	80	35	1.88	0.00	0.00	0.00
*Lenauheim	HBG	8	80	35	1.51	0.00	0.00	0.00
*Comlosu Mare	HB	5	70	35	0.73	0.00	0.00	0.00
*Grabat	GB	10	80	35	1.88	0.00	0.00	0.00
*Beregsau	GB	6	72	35	0.93	0.00	0.00	0.00
Timisoara	DB	10	50	35	0.63	1.00	1.98	0.10
Herculane	B	75	52	25	8.48	50.00	148.00	0.55
Olt Valley	DB	45	92	35	10.74	19.00	142.82	0.42
North Bucharest	HB	242	75	35	40.53	2.00	0.06	0.00
TOTAL		1,200.20			205.13	342.00	1,318.68	0.18

*) wells above 50°C wellhead temperature, without Exploration Permit (NAMR Licence), in stand-by;

**) maximum annual average flowrate approved by the NAMR Licence.

Table 4: GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS

Locality	Ground or water temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
TOTAL								

ERES = Qusable (1 – 1/SPF) EU RES Directive

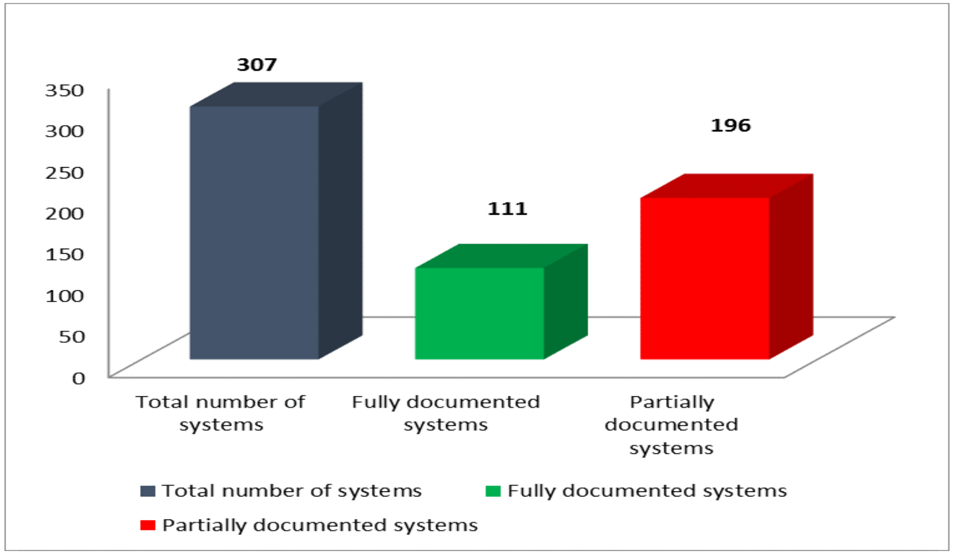
ERES, heating = Qusable,heating (1 - 1 / SPFheating)

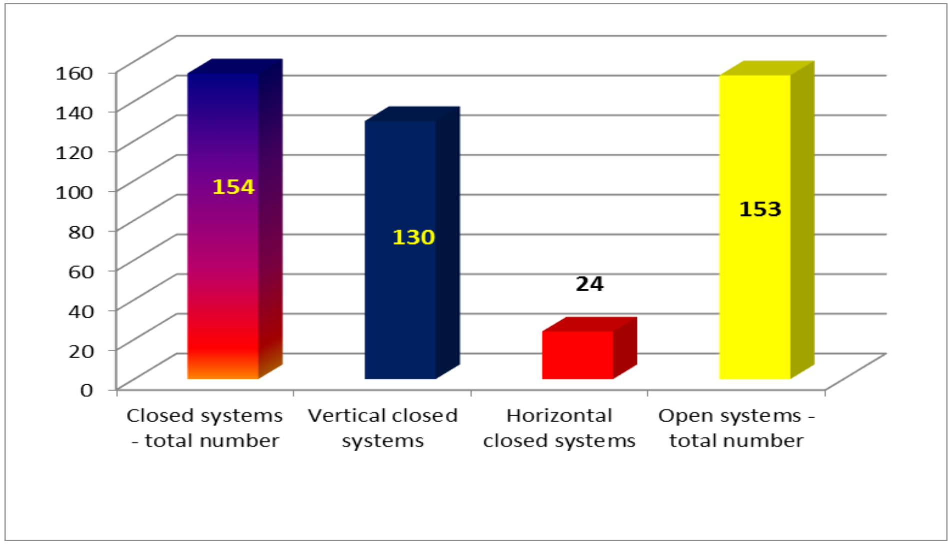
Eenvironment = Qusable,cooling (1 + 1/ SPFcooling) = Erecovered

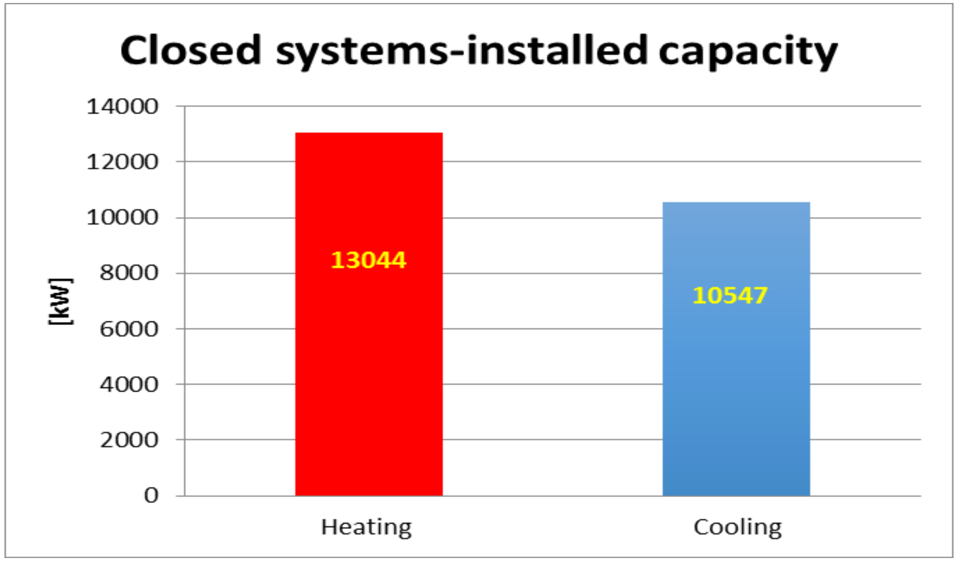
Romania has 5 climate zones, resulting in different full load heating hours per year and full load cooling hours per year for each climate zone (depending on the temperature bins)

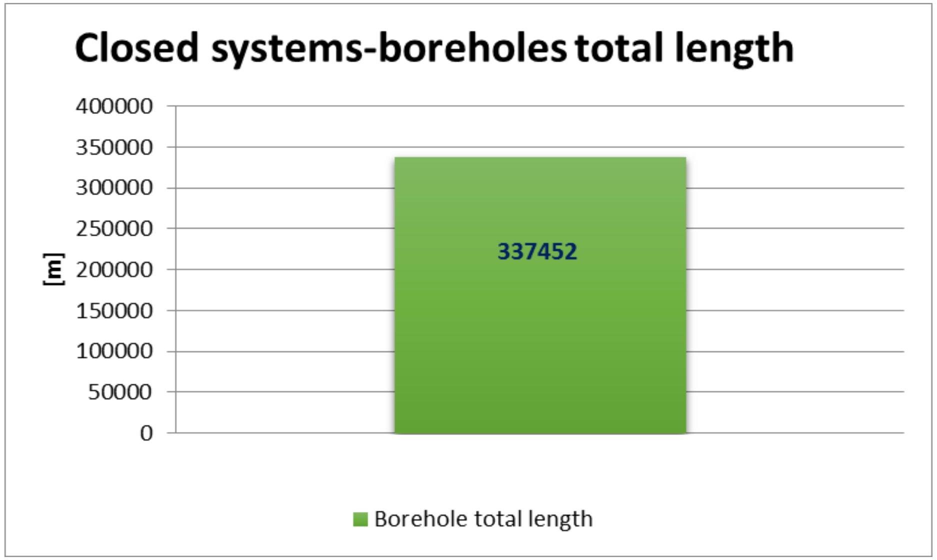
Contribution of all the installed GSHP systems in Romania: **28523 MWh_{th} renewable energy**, and **69 t savings in CO2 emissions** (in 2015).

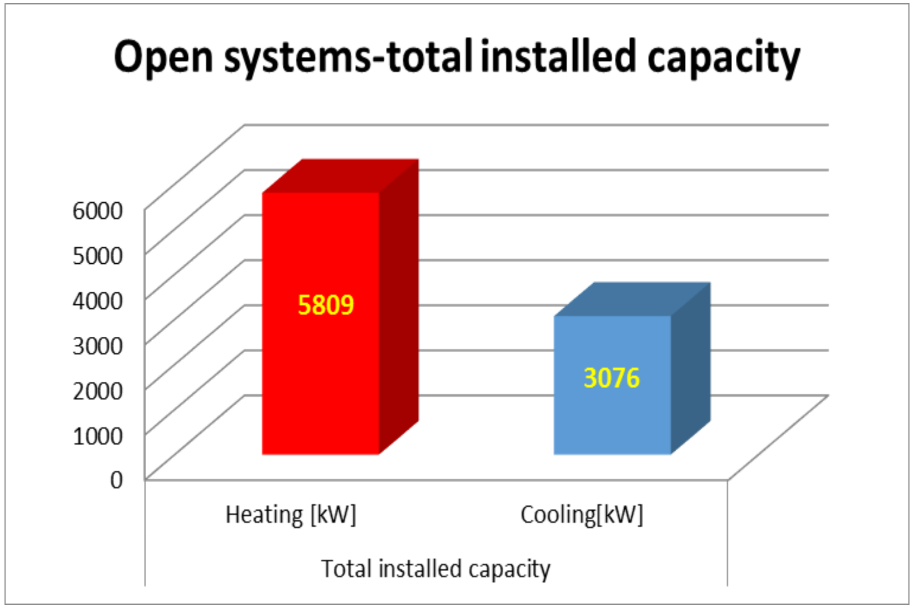
According to present data base. It is estimated that at least around other 300 systems are not documented at all.

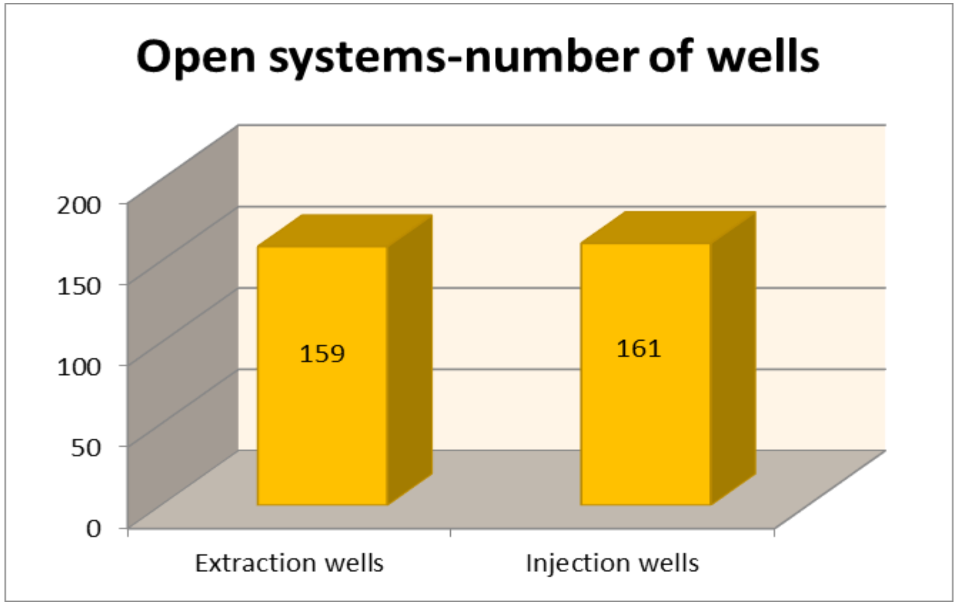

307
111
196
350
300
250
200
150
100
50
0
Total number of systems
Fully documented systems
Partially documented systems
Total number of systems
Fully documented systems
Partially documented systems

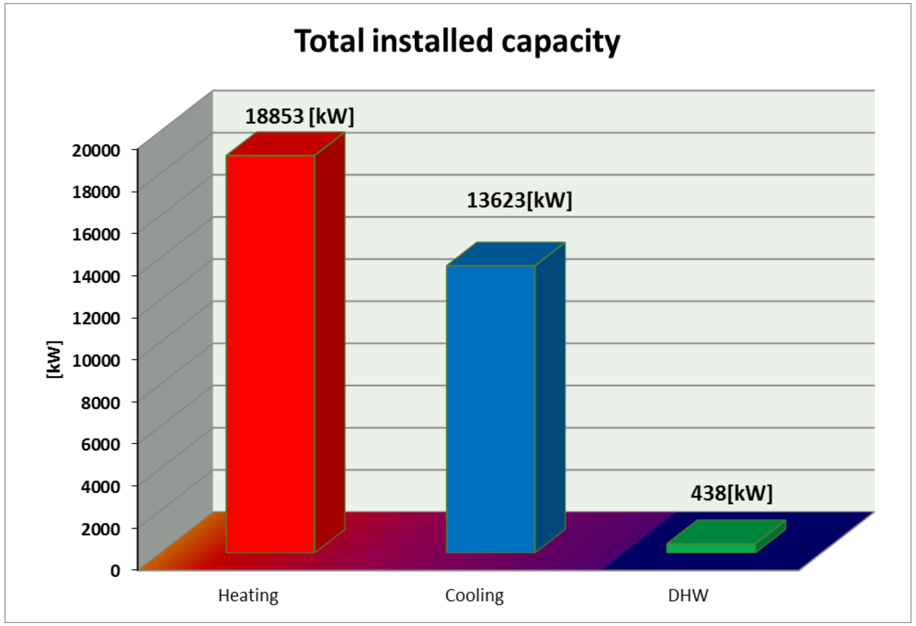

160
140
120
100
80
60
40
20
0
154
130
24
153
Closed systems - total number
Vertical closed systems
Horizontal closed systems
Open systems - total number

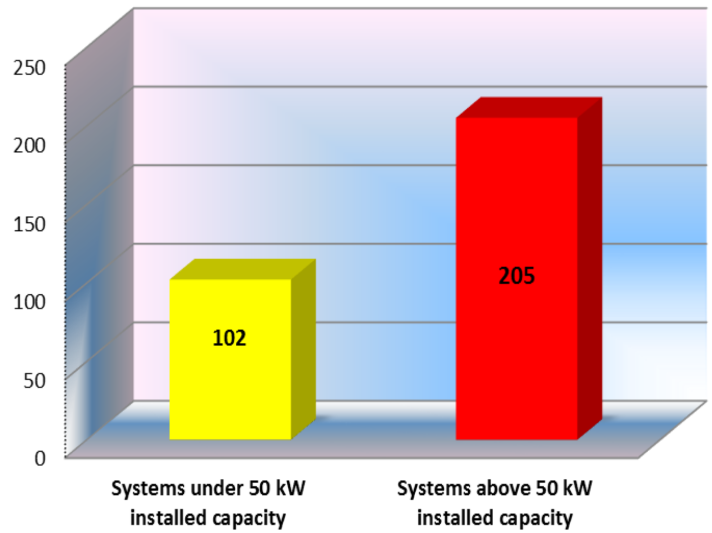

Closed systems-installed capacity
14000
12000
10000
8000
6000
4000
2000
0
[kW]
13044
10547
Heating
Cooling


Closed systems-boreholes total length
400000
350000
300000
250000
200000
150000
100000
50000
0
[m]
337452
Borehole total length


Open systems-total installed capacity
6000
5000
4000
3000
2000
1000
0
5809
3076
Heating [kW]
Cooling[kW]
Total installed capacity


Open systems-number of wells
200
150
100
50
0
159
161
Extraction wells
Injection wells


Total installed capacity
[kW]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
18853 [kW]
13623[kW]
438[kW]
Heating
Cooling
DHW


250
200
150
100
50
0
102
205
Systems under 50 kW installed capacity
Systems above 50 kW installed capacity

Otopeni City has replaced its geothermal DH system by a gas-boilers based DH system!

Table 5: SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual heating	29.63	207.28	0.22
District heating	78.31	616.17	0.25
Greenhouse heating	15.69	80.49	0.16
Fish farming	4.78	9.50	0.06
Drying agricultural products	6.32	12.70	0.06
Industrial process heat	3.75	6.84	0.06
Health and recreational bathing	66.65	492.34	0.23
Subtotal	205.13	1,425.32	0.18
Geothermal Heat Pumps	40	480.00	0.38
TOTAL	245.13		

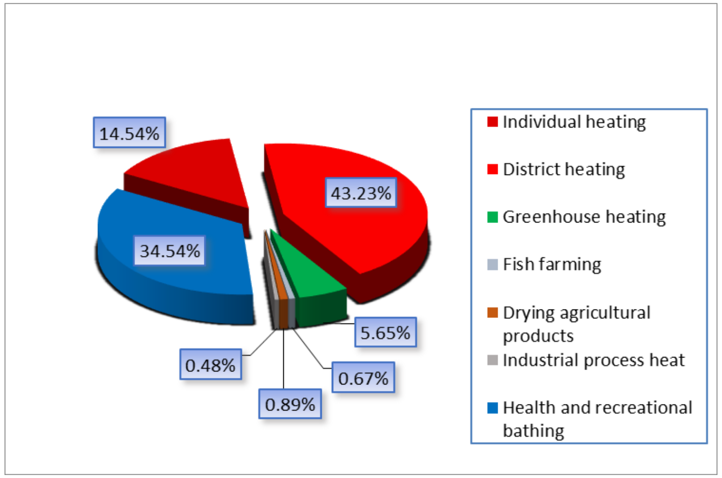


Table 6: WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2014 TO DECEMBER 31, 2019 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)	-	-	-	-	
Production	>150°C	-	-	-	-	
	150-100°C					
	<100°C	-	1	-	-	2.5
Injection	(all)	-	1	-	-	3
Total		-	2	-	-	5.50

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year		Professional Person-Years of Effort					
		(1)	(2)	(3)	(4)	(5)	(6)
2010		2	3	12	-	-	27
2011		2	3	12	-	-	27
2012		2	3	12	-	-	27
2013		2	3	12	-	-	25
2014		3	3	7	-	-	35
2019		4	3	9	-	-	40
Total		15	18	64	0	0	181

Table 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2019) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling Million US$	Field Development Including Production Drilling & Surface Equipment Million US$	Utilization		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %
2000-2004	4.4	3.6	4.5	-	56	44
2005-2009	2.7	4.6	2.1	-	14	86
2010-2014	-	4	1.5	0.2	30	70
2014-2019	-	4.5	10	0	75	25
2015-2020	-	-	-	-	-	-